Overview of the Strategic Planning Process in the Physics Laboratory

December 13, 2005

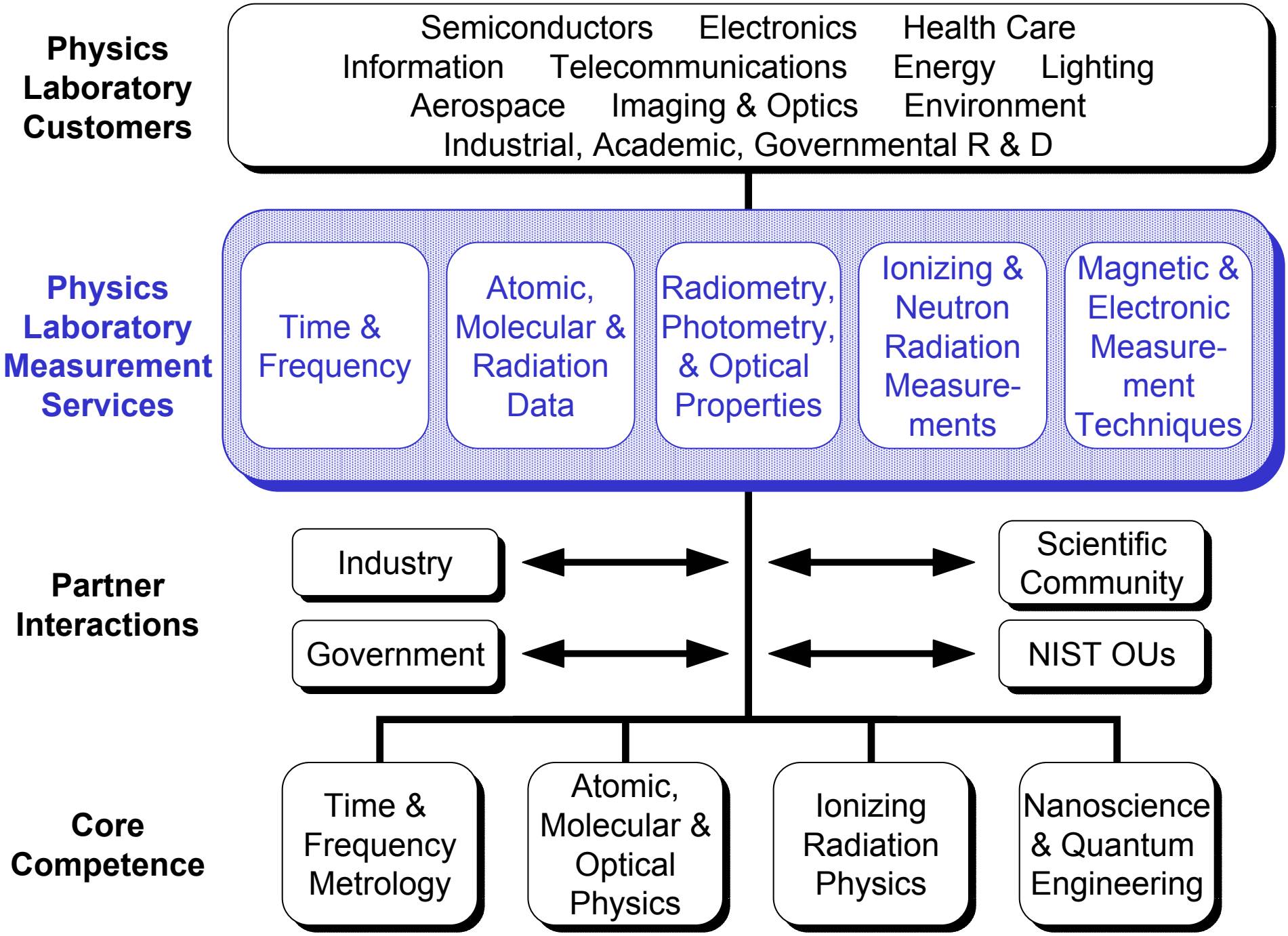
Katharine B. Gebbie
Director, Physics Laboratory

NIST
National Institute of Standards and Technology
Technology Administration
U.S. Department of Commerce

Physics Laboratory

Physics Laboratory supports the NIST mission by advancing measurement science and providing measurement services for electronic, optical, and radiation technologies.

- Provide measurement, calibration and data services
- Develop new standards & measurement methods
- Conduct an aggressive dissemination program
- Collaborate with industry to commercialize our innovations
- Pursue long-term research anticipating future needs


Physics Laboratory Customers
Semiconductors
Electronics
Health Care
Information
Telecommunications
Energy
Lighting
Aerospace
Imaging & Optics
Environment
Industrial, Academic, Governmental R & D
Physics Laboratory Measurement Services
Time & Frequency
Atomic, Molecular & Radiation Data
Radiometry, Photometry, & Optical Properties
Ionizing & Neutron Radiation Measure-ments
Magnetic & Electronic Measure-ment Techniques
Partner Interactions
Industry
Government
Scientific Community
NIST OUs
Core Competence
Time & Frequency Metrology
Atomic, Molecular & Optical Physics
Ionizing Radiation Physics
Nanoscience & Quantum Engineering

Physics Laboratory Programs

Established Technologies	Emerging Technologies
• Time and Frequency	• Quantum Information
• Optical Technology	• Biological Physics
• Ionizing Radiation	• Nanoscale Science

Objectives:

- Long-term stability of U.S. measurement scales
- Reliable provision of services
- Responsiveness to national needs

Time and Frequency

The only reason for time is so that everything doesn't happen at once.

Albert Einstein

Time flies like the wind. Fruit flies like bananas.

Groucho Marx

Time and Frequency Program

Standards and Services

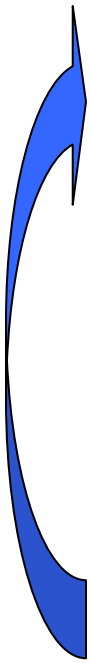
- Realization of Coordinated Universal Time (UTC)
- UTC dissemination through satellite, radio, Internet, etc.
- Frequency Measurement and Analysis Service
- Phase noise measurements

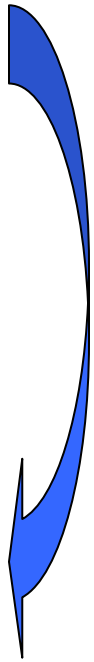
Standards and Technology Development

- NIST F-2 fountain clock, primary frequency standard
- Chip-scale atomic clocks
- Space-based ‘primary’ standards
- Broadly tunable reference oscillators

Measurement Science

- Optical atomic clocks
- Optical frequency synthesis
- Quantum metrology





Integrated Time and Frequency Program

UTC(NIST)
Time Scale

Radio Stations

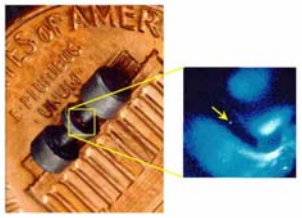
End Users

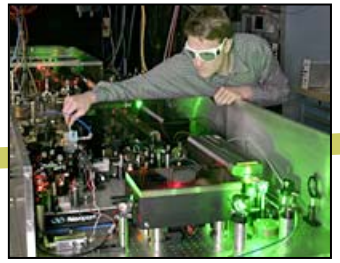
International Time
Coordination

Frequency
Measurement and
Analysis Service

Primary Frequency
Standards

Optical & Ion
Clock Standards

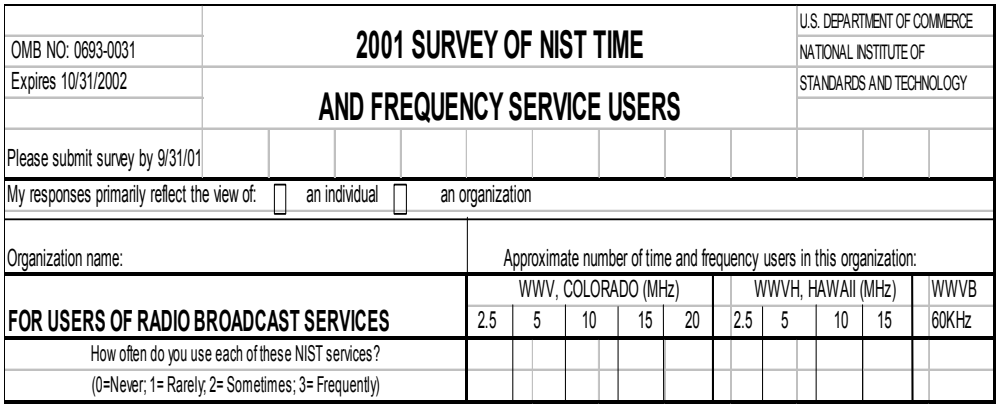




Optical Frequency
Synthesis

Determining Customer Needs

- Surveys about every ten years
  - 1987 survey ⇨ ACTS, ITS, & code changes
  - 2001 survey ⇨ 18,000 responses
- 10,000 phone calls and e-mails per year
- National and international standards committees
- Contacts with manufacturers of WWVB clocks and GPS receivers
- NASA and DARPA



	2001 SURVEY OF NIST TIME	U.S. DEPARTMENT OF COMMERCE
OMB NO: 0693-0031		NATIONAL INSTITUTE OF
Expires 10/31/2002	**AND FREQUENCY SERVICE USERS**	STANDARDS AND TECHNOLOGY
Please submit survey by 9/31/01		

My responses primarily reflect the view of: ☐ an individual ☐ an organization

Organization name:	Approximate number of time and frequency users in this organization:									
	WWV, COLORADO (MHz)					WWVH, HAWAII (MHz)				WWVB
FOR USERS OF RADIO BROADCAST SERVICES	2.5	5	10	15	20	2.5	5	10	15	60KHz
How often do you use each of these NIST services?										
(0=Never; 1= Rarely; 2= Sometimes; 3= Frequently)										

Responding to Customer Needs

Challenge:

WWVB: Poor reception and/or presence of interference, indicating marginal broadcast power

Response:

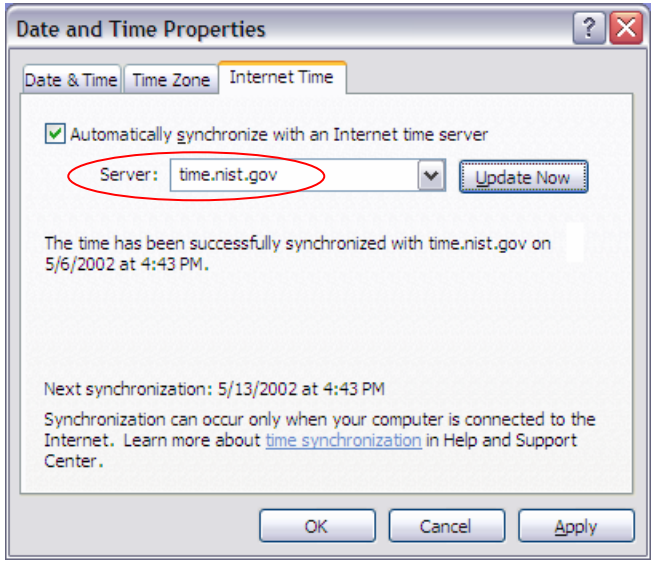
- Increase digital signal modulation with depth
- Publish recommended practices for radio-controlled timepiece manufacturers and users

Challenge:

ITS: Poor reliability or difficulty in use

Response:

- Increase number of servers:
  15 in 12 locations
- Automated load balancers
- Improved documentation



Optical Technology

Optical Technology Program

Standards and Services

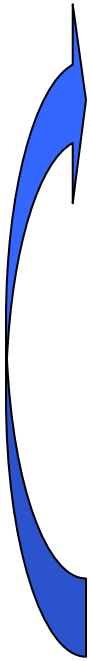
- Spectroradiometric calibrations
- Photometric calibrations
- Noncontact thermometry calibrations
- Optical properties of materials

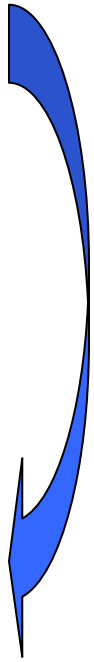
Standards and Technology Development

- Calibrations for remote-sensing systems
- Support for semiconductor manufacturing
- Colorimetry and appearance measurement
- Measurement methods for solid-state lighting (e.g., LEDs)

Measurement Science

- Improved detectors and methods, covering spectrum
- Ultrafast (femtosecond) lasers
- Vision Science [New competence]





Optical Technology Program Guidance

- Council on Optical Radiation Measurements (CORM)
- Standards development organizations
  (ASTM, CIE, IESNA, SAE, IEC, ...)
- Other Government agencies
  (DoD, CCG, NASA, NOAA, DOT, DOE, ...)
- Short course attendees
- Customers of calibration services

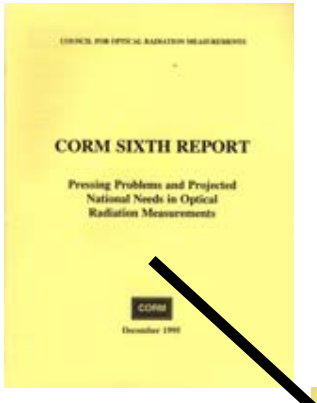
Council for Optical Radiation Measurements

- Established in 1972 as a non-profit organization to:
  - Establish consensus on national, industrial and academic requirements for physical standards, calibration services in optical radiation measurements
  - Establish consensus on national priorities to meeting these requirements
  - Liaise with NIST and advise on requirements and priorities
  - Cooperate with other organizations to accomplish objectives
  - Assure that information is widely disseminated
  - Answer inquiries about standards activities

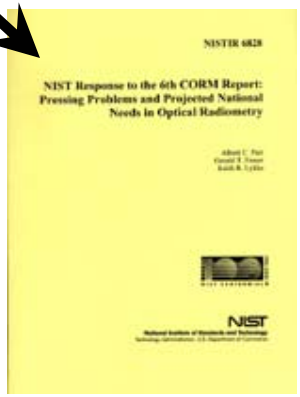
Council for Optical Radiation Measurements (CORM)

- Members include:
  - Approx. 150 companies from affected industries:
    - Photographic, ***Eastman Kodak, Polaroid, Canon***
    - Lighting, ***General Electric, Lumileds, Osram Sylvania, Philips***
    - Automotive, ***3M, Dupont, PPG, Truck-Lite***
    - Aerospace, ***Ball, Boeing, Honeywell, Rockwell Collins***
    - Instrumentation, ***Gamma Scientific, Hemmendinger, Hoffman Engineering, Instrument Systems, Keithley, Labsphere, LMT, Munsell, Optronic Laboratories, Oriel, Photo Research, Welch-Allyn***
  - 35 Government agencies
  - 25 Universities

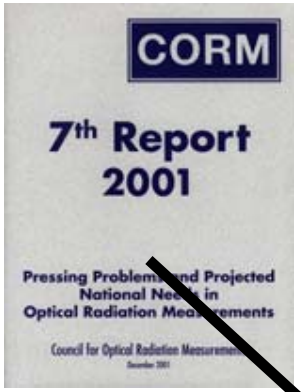
Establishing Priorities with Customers: Council for Optical Radiation Measurements



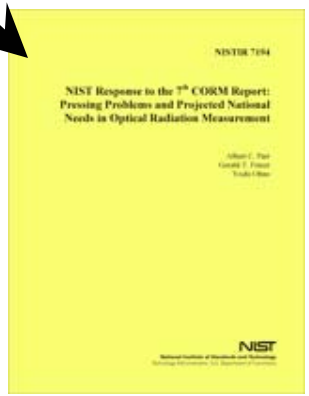
CORM 6th Report



NIST Response



CORM 7th Report



NIST Response

CORM 8th Report In Preparation

CORM 8th Report

← Annual Membership Meetings, Triannual Board Reports →

1995 2001 2001 2005 (2006?)

CORM Evaluation Criteria

- **Degree of need**: Will the proposed development solve a significant, troubling problem for a large number of users in the optical radiation community?
- **Probability of success**: Are we proposing something that we can reasonably expect to be accomplished?
- **Immediacy or urgency**: This category addresses the issue of timing. Will this proposal solve a problem that is disrupting the optical radiation community right now, or does the proposal address a problem that can be solved with a longer term, ongoing effort?
- **Economic factor**: This category addresses the importance of the proposed work with regard to its impact on US industry, trade, or other national priority.

CORM Seventh Report
Top Ten Recommendations (out of 15)

R-1	New standards for luminous flux (e.g., for LEDs)
R-2	New standards for luminous intensity (e.g., for LEDs)
R-3	New standards and definitions for luminance
R-4	New standards of spectral irradiance
O-1	New standards for reflected color
O-2	New standards for BRDF/BTDF
O-3	New standards for fluorescence
O-4	Regular transmittance standards
O-5	Standards and measurement of retroreflection
M-1	Measurement uncertainty

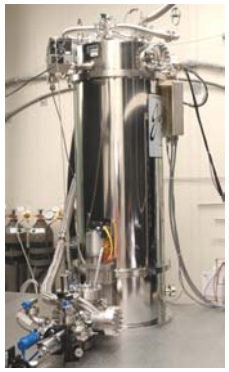
(Color indicates Priority 1 Items)

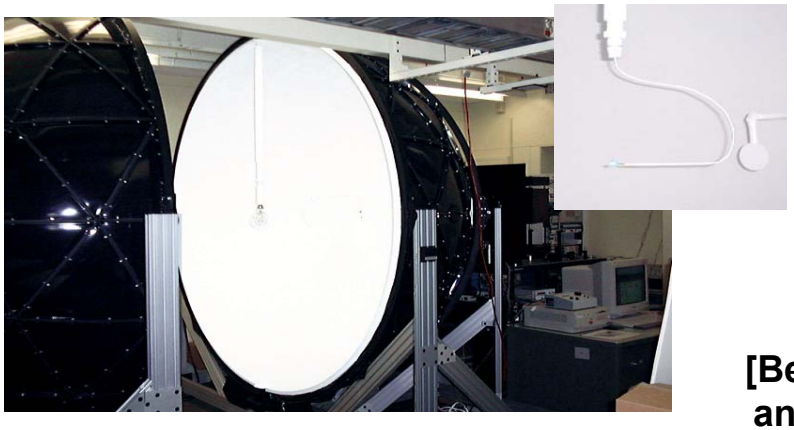
CORM Seventh Report
NIST Response

R-1	New calibration service (37130S)
R-2	New calibration service (37130S)
R-3	In research phase
R-4	New facilities (FASCAL 2, SURF UV)
O-1	New calibration service (38091S)
O-2	In development phase
O-3	Not active (resource intensive)
O-4	Had preexisting capabilities
O-5	New facilities, future services (DoT / NCHRP funded)
M-1	New facilities (POWR, SIRCUS)

(Color indicates Priority 1 items)

New Services and Facilities

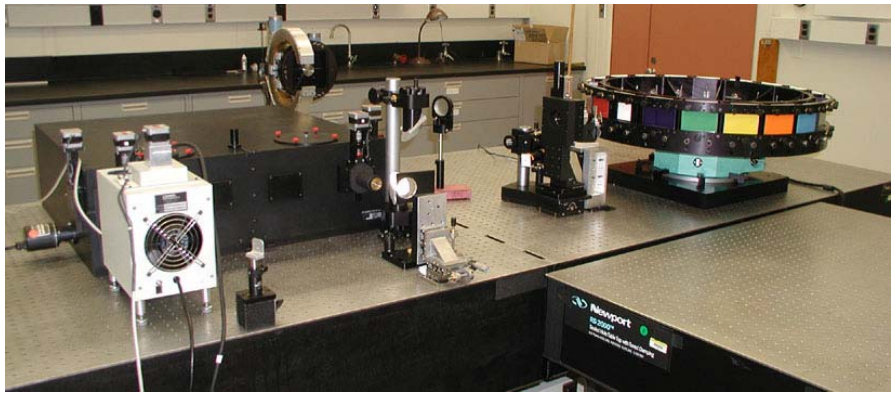




[Left] R-1, New Calibration Service for Luminous Flux of LEDs

[Left] M-1, Reduced Measurement Uncertainty using Primary Optical Watt Radiometer (POWR)

[Below] O-5, New Standards and Measurement Services for Retroreflection



[Above] O-1, New Calibration Service for Reflected Color

Ionizing Radiation

Ionizing Radiation Program

Standards and Services

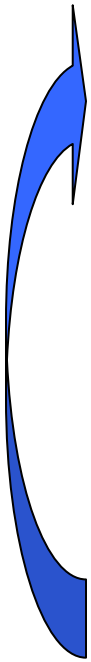
- Dosimetry: X-rays, gamma rays, electrons (SI unit, the gray)
- Radioactivity calibrations and standards (SI unit, the becquerel)
- Neutron sources and dosimetry
- Electronic Traceability (e-Certification)

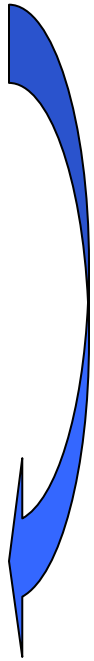
Standards and Technology Development

- Medical diagnosis and treatment
- Homeland security
- Energy and environmental
- Radiation processing

Measurement Science

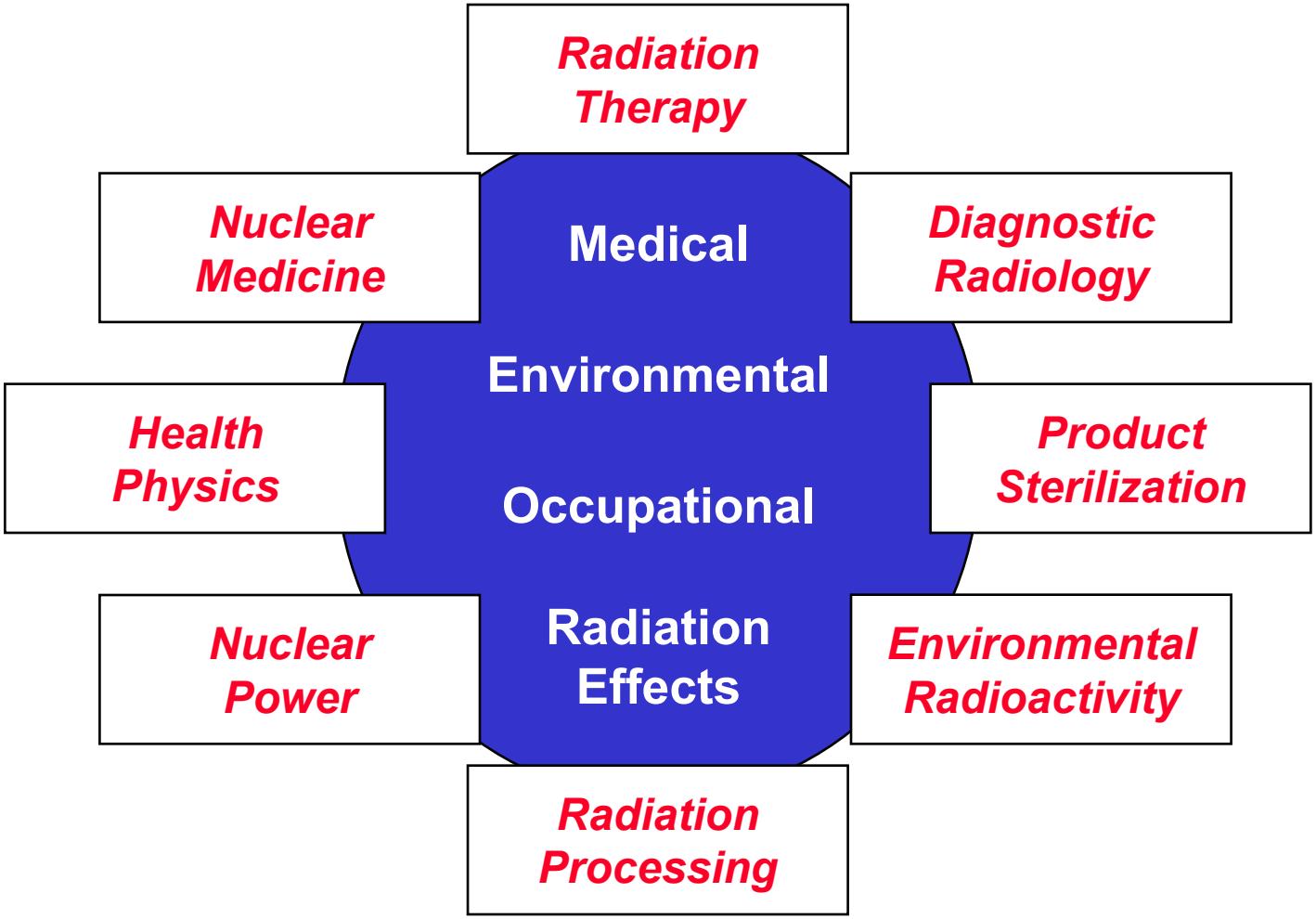
- Neutron Interferometry and Optics Facility
- High-energy x-ray tomography
- Metrology for alpha-emitting radiopharmaceuticals





Establishing Priorities with Customers: CIRMS

Council on Ionizing Radiation Measurements and Standards



Council on Ionizing Radiation Measurements (CIRMS)

- Members include:
  - Approx. 21 companies from affected industries:
    - Medical, ***Amersham Health (GE), Bristol-Myers Squibb, Best Medical, Bruker, Cardinal Health, Implant Sciences, International Brachytherapy, MDS Nordion, Nucletron, Theragenics***
    - Radiation Protection, ***Global Dosimetry Solutions, Landauer***
    - Industrial & Materials, ***Hopewell Designs, Sterigenics***
    - Homeland Security, ***AEA Technologies, Thermo Electron***
  - 11 Government agencies
  - 3 Universities

Meeting Customers' Priority Needs

Highest Priority Needs from CIRMS Triennial Needs Report

- **Needs in Health Care**
  - Standards for nuclear medicine
  - Dose mapping for therapy
- **Needs in Radiation Protection**
  - Transfer standards for neutrons
  - Bioassay metrology
  - Infrastructure for rad protection
  - Electronic dosimetry
- **Needs in Industrial Applications**
  - Mixed-field radiation effects
  - Medical device sterilization
  - Food irradiation
  - E-beam dosimetry

- **Efforts in Health Care**
  - Radionuclide calibrations/standards
  - Water calorimetry for accelerators
- **Efforts in Radiation Protection**
  - Comparisons of neutron calibrations
  - New SRMs (oyster, seaweed)
  - ISO beam qualities (40 added)
  - Internet-based real time calibrations
- **Efforts in Industrial Applications**
  - Dosimeter calibrations by fast neutron
  - Thin film alanine transfer dosimeters
  - Low temperature response of alanine
  - Transfer of calorimetry dosimetry to industrial setting

Monthly Usage of PL Websites Average, Dec 2004 – Nov 2005

- Gaithersburg:
  - Complete site: ~1.6 M/mo (~19.5 M/y)
  - Physical Reference Data: ~840 K/mo (~10 M/y)
  - Fundamental Physical Constants: ~170 K/mo (~2 M/y)
  - Atomic Spectroscopy Databases: ~330 K/mo (~4 M/y) which includes the following databases…
    - Atomic Spectra Database [Ver. 3.0] [Ver. 2.0] [Ver. 1.3]
    - Handbook of Basic Atomic Spectroscopic Data
    - Energy Levels of Hydrogen and Deuterium
    - Ground Levels and Ionization Energies for the Neutral Atoms
    - Spectral Data for the Chandra X-ray Observatory
    - Spectrum of Platinum Lamp for UV Spectrograph Calibration
    - X-ray Transition Energies
- Time and Frequency Division : ~330 K/mo (~4 M/y)
- time.gov: ~710 K/mo (~8.6 M/y)

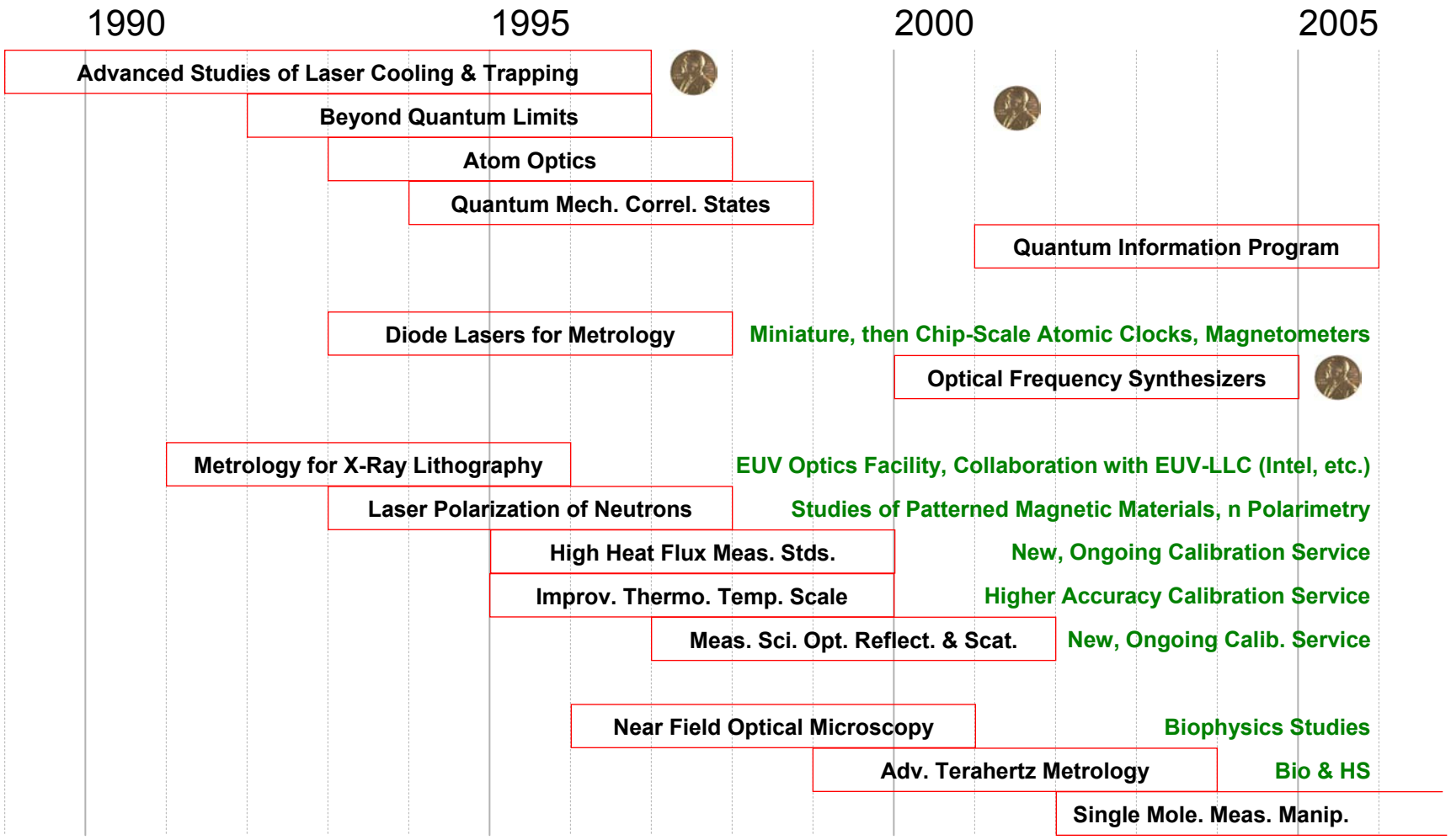
Physics Laboratory Programs

Established Technologies	Emerging Technologies
• Time and Frequency	• Quantum Information
• Optical Technology	• Biological Physics
• Ionizing Radiation	• Nanoscale Science

Objectives:

- Long-term stability of U.S. measurement scales
- Reliable provision of services
- Responsiveness to national needs

Strategic Use of Competence Funding



Beyond Quantum Limits

- **1992 Competence Initiative**
- ***Beyond Quantum Limits – Toward a Sensitivity Revolution in Optical Physics***
- Worldwide search for new QPD employee to achieve goals of the competence initiative.
- Program to be developed by Eric Cornell includes a major thrust to achieve **Bose Einstein Condensation** using a combination of magnetic and laser trapping methods on alkali atoms.
- Why is Bose Condensation important?
- Hall's competence initiative stresses a deeper understanding of fundamental quantum limits, as probed and measured by optical means.
- Bose Condensation is one of those limits.

Quantum Information

A radical departure in information technology, more fundamentally different from current IT than the digital computer is from the abacus.

William D. Phillips

There is no adequate defense, except stupidity, against the impact of a new idea.

Percy W. Bridgman

Quantum Information Program

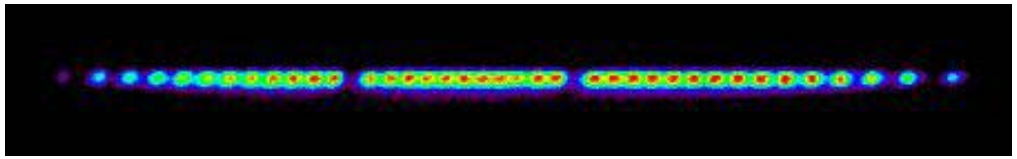
- Computing and communication
- Well coordinated with ITL and EEEL
- Directly applicable to NIST mission in time keeping and quantum- (Heisenberg-) limited measurement methods
- NIST computing goal of 10 qubit processor

"Emerging areas of research also can produce unforeseen consequences for security. The emergence of optical computing and intelligent agents, as well as in the longer term, developments in areas such as nanotechnology and quantum computing, among others, will likely reshape cyberspace and its security. The Nation must be at the leading edge in understanding these technologies and their implications for security."

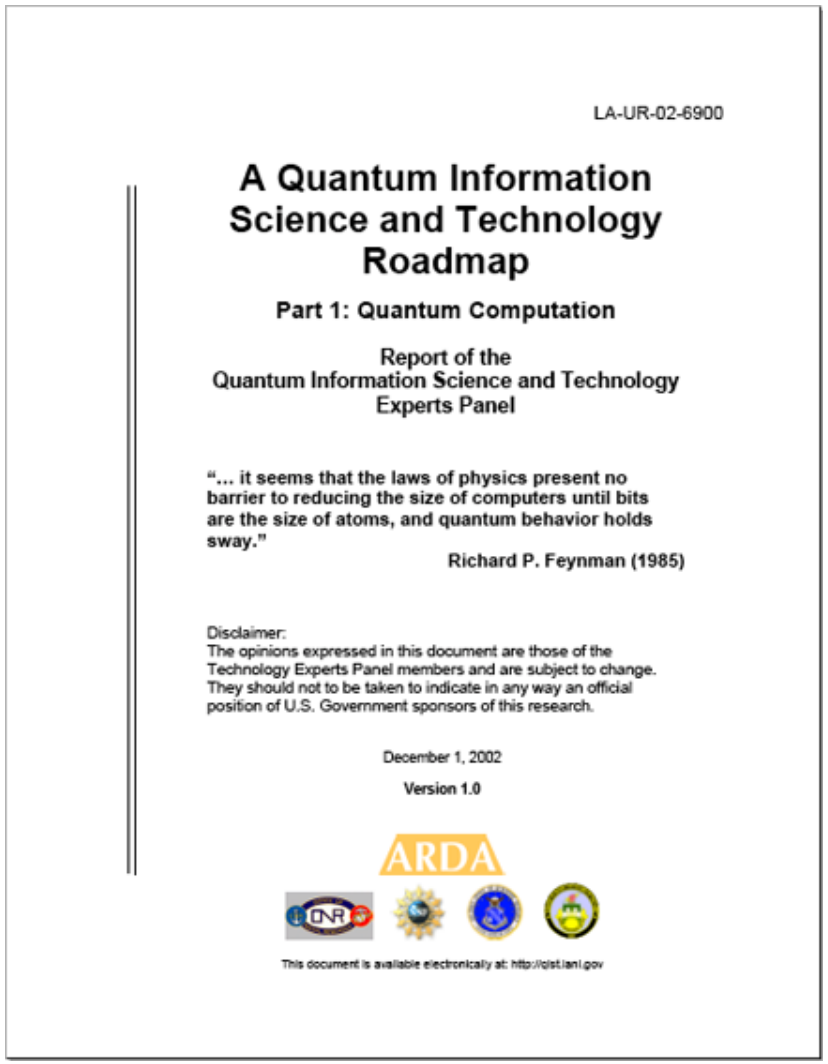
– ***The National Strategy to Secure Cyberspace*, President's Critical Infrastructure Protection Board** (now known as the National Infrastructure Advisory Council (NIAC)), **February 2003**

Quantum Information and Processing

- Workshop on Quantum Information Science and Emerging Technologies (QISET)
  - Boulder, Colorado, April 28–30, 2004
- Single Photon Detector Workshop
  - Gaithersburg, Maryland, April 30 – May 1, 2003



Quantum Information Roadmap



LA-UR-02-6900

A Quantum Information Science and Technology Roadmap

Part 1: Quantum Computation

Report of the
Quantum Information Science and Technology
Experts Panel

"... it seems that the laws of physics present no barrier to reducing the size of computers until bits are the size of atoms, and quantum behavior holds sway."

Richard P. Feynman (1985)

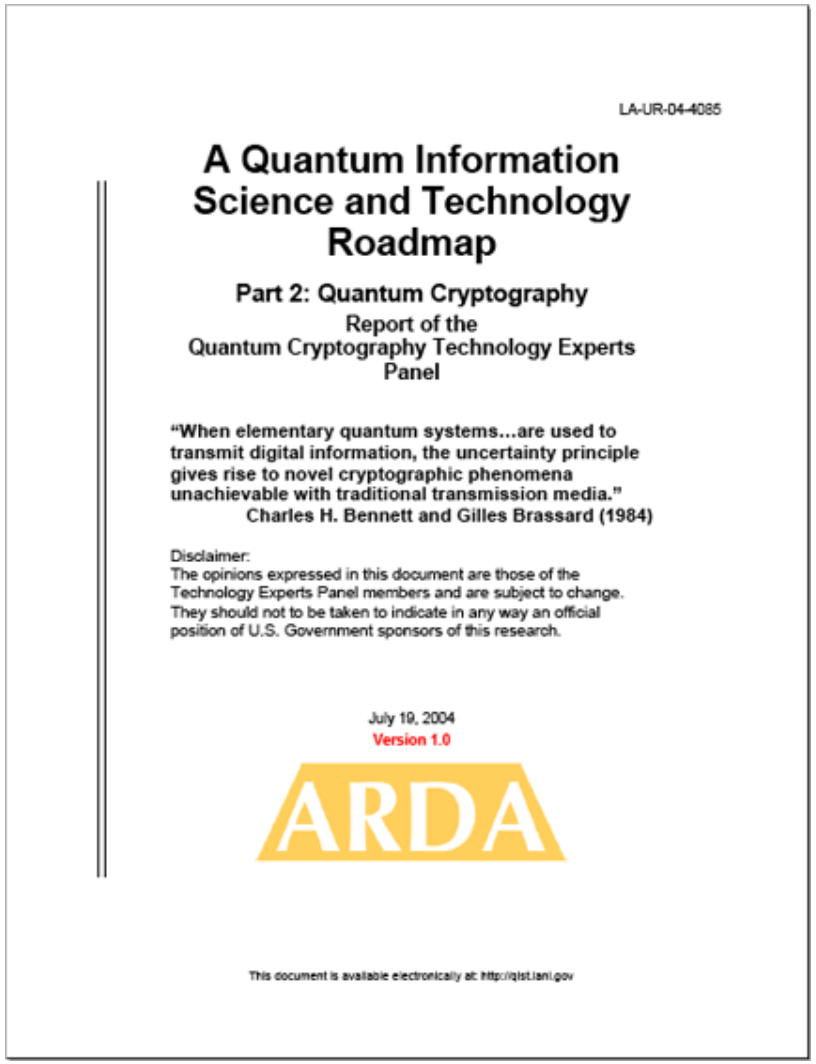
Disclaimer:
The opinions expressed in this document are those of the Technology Experts Panel members and are subject to change. They should not to be taken to indicate in any way an official position of U.S. Government sponsors of this research.

December 1, 2002

Version 1.0

ARDA

This document is available electronically at: http://qist.lanl.gov



LA-UR-04-4085

A Quantum Information Science and Technology Roadmap

Part 2: Quantum Cryptography

Report of the
Quantum Cryptography Technology Experts
Panel

"When elementary quantum systems...are used to transmit digital information, the uncertainty principle gives rise to novel cryptographic phenomena unachievable with traditional transmission media."
Charles H. Bennett and Gilles Brassard (1984)

Disclaimer:
The opinions expressed in this document are those of the Technology Experts Panel members and are subject to change. They should not to be taken to indicate in any way an official position of U.S. Government sponsors of this research.

July 19, 2004

Version 1.0

ARDA

This document is available electronically at: http://qist.lanl.gov

Biological Physics

The ultimate role for NIST, as I see it, is to provide the physical basis for quantitative measurement and a standards infrastructure for the medical community. This role is not being effectively addressed by any Federal entity.

Thomas M. Baer
Founder, Arcturus Bioscience
Consulting Professor in
Applied Physics
Stanford University

Biological Physics Program

- Youngest of the PL programs
- Based on years of experience in AMO and radiation physics
- Recognition of the potential of interdisciplinary contributions and the benefits of solid collaborations (e.g., with NIH, CU, UMd)

"Agencies should target investments toward the development of a deeper understanding of complex biological systems through collaborations among physical, computational, behavioral, social and biological researchers and engineers. …"

– FY 2007 Administration Research and Development Budget Priorities, OSTP/OMB, July 8, 2005

Nanoscale Science

The understanding and control of matter, at dimensions of roughly 1-100 nm, where unique phenomena enable novel applications....and the physical, chemical, and biological properties of materials differ in fundamental and valuable ways from the properties of individual atoms, molecules, or bulk matter.

NNI/NSTC

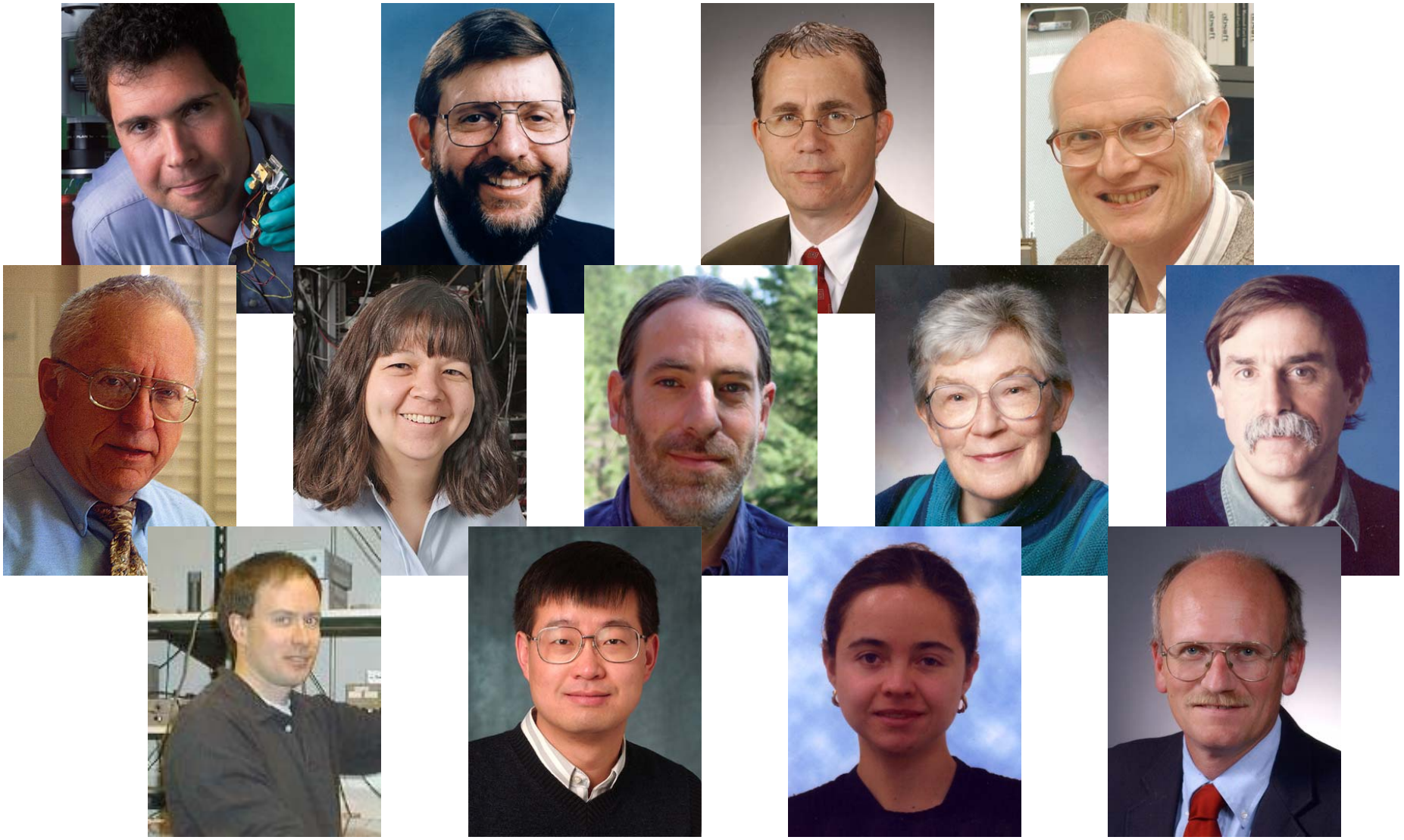
Nanoscale Science in Physics Laboratory

- Magnetics – Scanning Electron Microscopy with Polarization Analysis (SEMPA)
- Electronics – States in systems of reduced dimensionality
- Fabrication – Atom assembly, single-atom doping
- Coherent control of quantum systems
  - Bose-Einstein Condensations
  - Degenerate Fermi gases
  - The “quantum wiring” problem

Forefront Projects and Results

Recognition by the Press

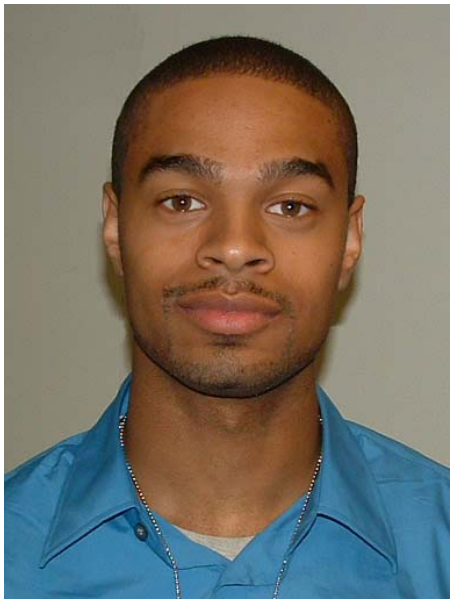
Major External Awards – FY 2005



Summer Undergraduate Research Fellowship (SURF) Program

Hosting New Orleans Expatriates

Prof. James McGuire



Mr. Malcolm Mitchell

Prof. Fred Wietfeldt